Pergamon

Phys. Chem. Earth (A), Vol. 25, No. 6–7, pp. 597–604, 2000

1464-1895/00/$ - see front matter

PII: S1464-1895(00)00090-9

Temperature Distribution and Anomalies in the Crystalline Basement of the Tataria Arch

N. N. Khristoforova, A. V. Khristoforov and R. Kh. Muslimov

Kazan State University, Department of Physics, Kazan, Russia. E-mail: Anatoly.Khristoforov@ksu.ru

Received 5 August 1999; revised 13 January 2000; accepted 6 April 2000

Abstract. We made temperature measurements in the crystalline basement of the superdeep and deep boreholes located in the central-eastern part of the East European platform. The basement in the studied region is characterized by an average heat flow of 60 $mW\ m^{-2}$. Our experiments have revealed temperature anomalies in the crystalline basement that we interpreted as unconsolidated zones. The studies indicate that fluid injection anomalies, sheet flow and overflow zones and gas anomalies can be detected by temperature measurements.

1 Introduction

By use of the geothermal observation in the basement, we studied two problems, (1) the thermal regime of the Earth's crust and heat flow from interior, and (2) the location of temperature anomalies related to unconsolidated zones (zones in a loosely aggregated form) in the crystalline basement of the Tataria arch.

The study of crystalline basement is important because of the presence of possible economic resources, for example, petroleum deposits and because many fundamental geophysics problem related to terrestrial heat flow are best solved from studies of the basement.

Temperature and heat flow investigations in the basement are published for the Precambrian shields where crystalline rocks are located near the Earth's surface (Čermák and Rybach, 1979; Hurtig et al., 1991). However, as geothermal evidence suggest (Kozlovsky, 1984; Khristoforova et al., 1997; 1999) there is a reason to believe that there are large differences in the thermal regime of the deep and subsurface basement.

In East Europe temperature measurements in sufficiently thick strata of crystalline basement were made in the superdeep holes: Kola (Kozlovsky, 1984), Minnibayevskaya 20000 (Muslimov et al., 1980) and Novo-Yelhovskaya 20009 (Khristoforova et al., 1997).

Major questions that need answers are:

What are the temperature anomalies in the basement and what is their origin? Are there unconsolidated permeable zones in deep crystalline basement?

What are the values of temperature gradient (G) and heat flow (q) in deep crystalline basement?

We made temperature measurements in the crystalline basement in 10 deep and 2 superdeep wells. They provide an insight in the top 5 kilometers or so of the basement of the Tataria arch and allow to answer some of the questions above for this region.

2 Short Characteristics of the Basement in the Tataria arch region

The experimental study of temperature in the granite-gneiss layer of the Earth's crust was made in the holes located on the South uplift of the Tataria arch in the central-eastern part of the East European platform, Fig.1.

Tataria arch is one of the largest geologic features of the Volga-Ural petroleum-bearing basin. Many oil fields including such large ones as the Romashkinskoye and Novo-Yelhovskoye oil fields are located over the South uplift. Drilling revealed that the basement is thick strata of granite-gneiss rocks of Archean age beneath the Paleozoic sedimentary strata. The basement top on the South uplift is at a depth of about 1700m, it goes down to depths over 2400m at its slopes (transition zones from arch to depressions) (Muslimov and Lapinskaya, 1996).

Crystalline basement is alternating-layered strata of the high-grade metamorphic rocks of both sedimentary and igneous origin. They are penetrated by intrusions along faults. The main rock types are gneisses, granites and crystalline schists. Gabbro-diabase dikes, mylonites and shear zones have been identified in the basement. The South uplift consists of a number of blocks, joint by large faults. The basement is intervenedby troughs trending north-south. Drilling results confirm the exis-